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PANEL SESSION

Hydro Power Technology

PROSPECTS OF HYDRO SMALL AND BIG AS A RENEWABLE ENERGY RESOURCE IN CANADA AND ABROAD

Date: Oct. 25, 2007 (4:40PM – 6:30PM)
Location: IEEE EPC 2007 venue, Montreal, Quebec
Panel Session Title: **Hydro Power Technology - Prospects of Hydro Small and Big as a Renewable Energy Resource in Canada and Abroad**
Panel Session Chair: **Stan Pejovic, University of Toronto**
Panel Session Facilitator/Moderator: **Carl Vansant, HCI Publications, Kansas City, Missouri**

Background Information:
Small and large scale hydraulic energy takes considerable and renewed interest from various points of view: the high energy density, the land diffusion of a lot of unexploited resources, the availability in this sector of a well known technology, and the continuous and often very fast rising fossil fuels prices. In addition, these micro hydro plants can be easily inserted in irrigation or water distribution projects, taking advantage of lower costs

The growth of both electricity demand and subsequent production and supply, and particularly the related interest in hydropower, is of world wide scope and significance. It is a growth and interest that shows no sign of decreasing or letting up. At yet there is also no doubt that hydropower plant design, construction and operation are complex tasks. To name only a few, such an undertaking requires environmental and hydrological assessments, careful planning and design, visionary financing and long-sighted political planning, demanding construction and supervision, painstaking commissioning and trouble shooting, and meticulous operation and control. Tens of thousands of details must be accurate, well conceived and executed, and carefully coordinated for a project to achieve safe and economical operation that can be judged a social, technical and environmental success. Yet, when only a few of these myriad details are overlooked, under-estimated or improperly linked to each other, great complications can quickly arise.

Small hydro power plants – especially those incorporated in larger systems – often suffer from the same problems as the large ones. The analysis of operating regimes may be much more complicated, due to complex boundary conditions. On the other hand, the general tendency is to decrease the cost of design and, therefore, to simplify the analysis. Thus, in general, the smaller hydroelectric plants imply the higher risk of having troubles resulting from reduced project costs. Saving money reducing reviewing costs further increases the risk.

Continuity has been lost. Canada (and the World) has had more than 100 years of experience in the electricity sector but individual areas have lost valuable experience and knowledge that accrued during this period. Poorly coordinated transfer of practical and theoretical experience appears to be the root cause. The consequences are an unstable market and investment climate, accidents, inefficiency and troubleshooting (of the same problems) which have all shown up regularly in recent years and will continue in the future if appropriate steps are not taken. The organized multidisciplinary transfer of experience is a major task that needs to be undertaken by the

universities and electricity sector in Canada (and worldwide); so it is urgent that decisions be made (or perhaps should have already been made). There is a clear need to plan, finance and implement some long-term initiatives.

The greatest task facing the electricity sector in Ontario, Canada, and worldwide is the design of new generators and the rehabilitation of nearly all existing units within a short time frame, yet there are too few experienced experts (engineers) and project managers who know how to cultivate the right skills from the market place. An expert to be able to design the hydroelectric plant as the team member should have 10 to 15 years organized trainee on sites and in schools.

Program Agenda:

- **Opening** by Stan Pejovic, Chair
- **Introduction "**Minimizing Risk during the Process of Hydroelectric Project Design" by Carl Vansant, Moderator,
- **Panel Session Presentations:**
  Presentation 1: "Hydro Hydraulics - a Disappearing Art?" by J.L. Gordon
  Presentation 2: "Transient System Response of a Hydro Scheme with an Air Pocket" by S. Hunt
  Presentation 3::Breimer E.R., Kostic M., Compact Electrical System for Small Hydro
- **Closing Conclusions and Recommendations** by Stan Pejovic, Chair

Program Details:

OPENING:

Chair's Bio:

Dr. Stanislav Pejovic *was born in Belgrade, Serbia and received his Ph.D. Degree from University of Belgrade. At the Department of Mechanical Engineering he served various positions, and was full professor until 1998. Since 2002 he is teaching at the University of Toronto and Ryerson University, Toronto. He has also lectured on specialized subjects related to energy, thermodynamics, physics, fluid mechanics, design of power plants and hydraulic transient analysis (waterhammer, vibrations, hydraulic vibrations, stability, resonance in technical systems and human blood vessels) as the visiting Professor at the University of Singapore, Hong Kong, Sarajevo and Skoplje, Nis, to name a few. He specializes in design, construction, commissioning, maintenance, troubleshooting and review of electric plants, hydraulic systems, pumps and turbines as well as the complex systems of thermal and nuclear plants. He has designed 27 power plants, 3 test rigs, a number of pumped storage plants and pumping systems; successfully completed hydraulic transient and vibration analysis for 31 large hydraulic machines and systems; developed model acceptance tests of 11 rotating (turbo) machines, field tests of 12, and acceptance tests of 7 power plants and has led numerous final field tests as Chief Engineer. He published 20 textbooks and monographs, as well as over 140 technical papers. He is the author of several books on vibrations, hydraulic transients, and a co-author of: "The Guide to Hydropower Mechanical Design", prepared by ASME Hydro Power Technical Committee, 1996 (new edition is under review), as well as "Guidelines to Hydraulic Transient Analysis", 1992; and 1987. He has acted as consulting engineer on design, construction, on-site and model tests of power plants and computer simulation of transient and hydraulic vibration of many systems. At "Energoprojekt", Belgrade, he designed and tested the highest, at the time, (600 m) head Pumped-Storage Power Plant "Bajina Basta", and a number of other electric power plants and pumping systems; designed the second phase for four small plants "Vlasina" having five units rated at 13 to 16 MW and the pump plant "Lisina" pumping into "Vlasina" storage. He has been involved in troubleshooting in the US, Canada, and Iran, and is a licensed Professional Engineer in the Province of Ontario.*

INTRODUCTION:

Topic and Title: Minimizing Risk during the Process of Hydroelectric Project Design
Speaker: Carl Vansant, Moderator,

Speaker's Bio: *Carl Vansant is a principal at HCI Publications, Kansas City, Missouri. He participates in guiding the strategic direction of HCI. Started in 1980, HCI is a key provider of information to, and facilitator of information exchange within, the hydropower industry worldwide. The organization provides multiple products and services to the hydropower industry. Carl Vansant is editor-in-chief at HCI Publications. He contributes to development of the content for HRW and Hydro Review magazines, Hydrowire and HydroWorld Alert newsletters, conferences, books, and other materials that serve hydroelectric industry professionals. Mr. Vansant holds degrees in engineering and is a registered Professional Engineer. He has worked in the energy field for more than 30 years. He is the author of and contributor to numerous papers, books, and presentations relating to energy supply. He has worked as an engineering consultant and project manager, overseeing dozens of projects ranging from feasibility and siting investigations to power plant design projects. Mr. Vansant is a recipient of the highest awards conferred upon hydroelectric professionals in the United States: the Dr. Kenneth Henwood Award, conferred by the U.S. National Hydropower Association, and the Rickey Medal, awarded by the American Society of Civil Engineers.*

PANEL SESSION PRESENTATIONS:

PRESENTATION 1:

Topic and Title: Hydro Hydraulics - a Disappearing Art?
Speaker: Jim L. Gordon

Abstract:

Over the past decade, there have been several instances where the performance of new hydro developments has been compromised by unsatisfactory operation of some component associated with the hydraulic design of the facility. This paper will outline the types of deficiencies encountered, and suggest some remedies. The incidents include – gravel entrainment at intakes; "burping" intakes; design of surge tanks; high head penstock friction; design of relief valves; turbine runner blade – wicket gate interaction; turbine draft tube rope – pipeline interaction; isolated system operation and draft tube water column rupture. Unfortunately, the author is unable to name the projects, nor provide more adequate details which could facilitate identification of the project. Owners do not appreciate information on "incidents" being divulged, and the author has signed confidentiality agreements on most of the facilities being discussed. Hence, the "incidents" have to be taken as anecdotal, but the author can vouch for their authenticity.

Speaker's Bio: ***Jim Gordon*** *graduated from Aberdeen University in 1952 with a first class honours degree in Civil Engineering and commenced work with Montreal Engineering. During this time he was the Chief Design Engineer for 6 hydro projects which received awards "for excellence in design" by the Association of Consulting Engineers of Canada. He has worked in 15 countries, and for 9 years he was the Vice-President Hydro, retiring in 1990. Since then, he has practiced as a private consultant, providing advice to consultants and hydro utilities on design, cost, mechanical equipment selection, and has served on many review boards. He was awarded the Rickey Medal by the American Society of Civil Engineers, and the Distinguished Service Award by the Association. He has authored or co-authored 78 papers covering a wide range of subjects, from vortices at intakes, to turbine cavitation and generator inertia. He has been an invited speaker at 23 seminars.*

PRESENTATION 2:

Topic and Title: Transient System Response of a Hydro Scheme with an Air Pocket
Speaker: Stephen Craig Hunt

Abstract:

The presentation will highlight a surge pressure issue that is (to my knowledge) very seldom investigated within either large or small hydro-electric schemes namely, the presence and effects of a discrete air pocket within the system. Recent

studies have been undertaken (by HAL) to determine the magnitude of the pressure surges due to isolation valve opening when the section between the valve and the turbine has drained out and hence the pipe section is empty and the air pocket is at atmospheric pressure. The studies have shown that with rapid (but realistic) valve opening times, then surge pressures well in excess of the system's ratings can be generated, dependent on the size of the air pocket. The presentation will highlight the basic phenomena (rapid water column acceleration followed by equally rapid deceleration) that leads to the generation of the transient pressures and will also show the transient response in a 'video format' of the dynamic simulation. This video will be a three-dimensional mathematical representation of the pipeline system i.e. distance against internal pressure with time. It is appreciated that the actual methods and processes of the calculation of the transient pressures and flows is well documented and it is not intended to cover 'old ground'. However, the presentation will highlight to the attendees the importance of undertaking detailed hydraulic assessments of any hydro-electric scheme, no matter how small. It is often the case with a relatively low head system that a comparatively low pipeline and equipment pressure rating is proposed. This presentation will show that this could be a seriously flawed design consideration.

Speaker's Bio: Since 1979 S. Hunt worked with Hydraulic Analysis LTD. as an engineer in the Laboratory and Mathematical Studies, Senior Engineer in Mathematical Studies, Engineering Manager in Water & Sewage Projects. He is currently the Engineering Director for Overall Responsibility for Management of Company Projects (project control, training and technical supervision of engineering staff and advising on software development for all water, sewage & petro-chemical projects. Director in charge of co-ordinating Quality Management System to ISO 9001:2000). Mr. Hunt obtained his B.Sc.(Hons) Civil Engineering, from Leeds University in 1976 and obtained his Ph.D - "The Analysis of Unsteady Friction in Fluid Flows" in 1979. Mr. Has many publications.

PRESENTATION 3:

Topic and Title: Compact Electrical System for Small Hydro

Speaker: Miroslav Kostic M and Edward Breimer

Abstract:

Development of small hydro plants is always being faced with the constraints of economic feasibility including limitations such as physical space. Any space saving that can be achieved helps improve the economic and environmental viability of the project. High integration of secondary circuits' devices and functions through microprocessor-based technologies has already been utilized to great extent, realizing significant savings to power industry. Primary equipment on the other hand, and switchgear in particular, has not shown equivalent downsizing trends since the introduction of SF6 technology. While the benefits of SF6 technology are attainable at higher voltage levels, small hydro is usually associated with lower system voltages. Superconductors and semi-conductor based circuit interrupters are still not available for commercial use in the power industry. However, a combination of older and more current technologies can help minimize space and cost requirements for small hydro. This paper offers a review of a compact electrical system configuration with a brief description of power, protection, control, communications and metering segments.

Speaker's Bio:

Miroslav Kostic *studied Electrical Engineering at the University of Belgrade in Serbia. After graduating in 1984 he joined the P&C department at power transmission company Elektroistok. He worked for seven years as a P&C engineer and manager at the regional office in Krusevac. In Canada, Mr. Kostic worked for Etobicoke Hydro and Westinghouse Services, prior to joining Eaton Electrical in 1998. He has designed and commissioned electrical systems for gas and hydro generating stations, HV transformer stations, and a variety of industrial and commercial systems. In addition, he performs power system studies, provides course instructions on protective relaying and works as project manager. Miroslav Kostic is a licensed professional engineer in the province of Ontario.*

Edward Breimer *received a B.Sc. in Electrical Engineering from the University of Waterloo in 1986. Mr. Breimer has over nine years experience as a project manager of major projects with Eaton Electrical Service & Systems, specializing in energy related projects. Prior to this, he worked as an electrical engineering consultant, specializing in electrical system studies, ground grid design and electrical system design for Industrial facilities. In 1996, he participated in the*

preparation of Technical Research Report for the Canadian Electrical Association titled, "Low-Cost Control and Protection Systems for Mini-Hydro Intertie". Mr. Breimer is a member of IEEE and a Registered Professional Engineer in the Province of Ontario.

CLOSING CONCLUSIONS AND RECOMMENDATIONS:

Topic and Title: Conclusions and Recommendations

Speaker: S Pejovic, Chair

CONCLUSIONS AND RECOMMENDATIONS

I. WHOM TO SEND TO?

What is the best way to protect investors (owners) wasting money. What is the best way to protect young inexperienced engineers and experts doing work not experienced and properly qualified to do!

We need your help how and whom to send this conclusions and recommendations to:

(i) key professional and institutional organizations,
(ii) key political figures,
(iii) key educational organizations,
(iv) key regulators.
(v) Who else?

II. HYDRO DEVELOPMENT

Any hydroelectric installation, as a rule, should be designed using the following stages:

(i) Feasibility study,
(ii) General design,
(iii) Detailed design (after bidding),
(iv) Commissioning and running - in process,
(v) Trouble-shooting investigations, and
(vi) Reconstruction, redesign, adjustment or enlargement.

(vii) Review at each stage.

Ideally, all project documentation should be reviewed at each critical stage by independent reviewers selected and nominated by official authorities (provincial (state) and/or Canadian (federal) resource agencies). Short-changing the analyses, without justification, or worse yet, neglecting any design stage or its associated review, puts the project at risk. At stake here is the economical and efficient functioning of the whole project; taking short cuts can lead – and indeed has often led – to large-scale problems. The point here is that the design team, the project documentation, and the review process all play an interconnected role in anticipating and resolving difficulties before they are implemented in the field, and thus solving them when they are relatively simply addressed.

III. CONCLUSIONS

The growth of both electricity demand and subsequent production and supply, and particularly the related interest in hydropower, is of world wide scope and significance. It is a growth and interest that shows no sign of decreasing or letting up. At yet there is also no doubt that hydropower plant design, construction and operation are complex tasks. To name only a few, such an undertaking requires environmental and hydrological assessments, careful planning and design, visionary financing and long-sighted political planning, demanding construction and supervision, painstaking commissioning and trouble shooting, and meticulous operation and control. Tens of thousands of details must be accurate, well conceived and executed, and carefully coordinated for a project to achieve safe and economical operation that can be judged a social, technical and environmental success. Yet, when only a few of these myriad details are overlooked, under-estimated or improperly linked to each other, great complications can quickly arise.

Continuity has been lost. Canada (and the World) has had more than 100 years of experience in the electricity sector but individual areas have lost valuable experience and knowledge that accrued during this period. Poorly coordinated transfer of practical and theoretical experience appears to be the root cause. The consequences are an unstable market

and investment climate, accidents, inefficiency and troubleshooting (of the same problems) which have all shown up regularly in recent years and will continue in the future if appropriate steps are not taken. The organized multidisciplinary transfer of experience is a major task that needs to be undertaken by the universities and electricity sector in Canada (and worldwide); so it is urgent that decisions be made (or perhaps should have already been made). There is a clear need to plan, finance and implement some long-term initiatives.

The greatest task facing the electricity sector in Ontario, Canada, and worldwide is the design of new generators and the rehabilitation of nearly all existing units within a short time frame, yet there are too few experienced experts (engineers) and project managers who know how to cultivate the right skills from the market place. An expert to be able to design the hydroelectric plant as the team member should have 10 to 15 years organized trainee on sites and in schools.

IV. ASME HYDRO POWER TECHNICAL COMMITTEE

American Society of Mechanical Engineers (ASME) Hydro Power Technical Committee is editing the new updated version of *The Guide to Hydropower Mechanical Design*, planned for February 2009 (First edition: *The Guide to Hydropower Mechanical Design*, ASME Hydro Power Technical Committee, HCI Publications, 1996). It is already under consideration the recommendation similar to section I. Whom to Send to?

What is the best way to protect investors (owners) wasting money. What is the best way to protect young inexperienced engineers and experts doing work not experienced and properly qualified to do!

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(vii) key political figures,

(viii) key educational organizations,

(ix) key regulators.

(x) Who else?

Hydro Development to be discussed and added to the Chapter II Basic Consideration, new ASME Guidelines.

All other important and critical issues related to the plant design and construction should be treated in similar way specified in the previous text.

V. ACTION AT THE UNIVERSITY OF TORONTO

A. Case studies

Division of Environmental Engineering and Energy Systems, University of Toronto, has decided to support editing and writing the book on, The Current State of Technology in Hydraulic Machinery and Cases in Hydraulic Plants Design, Construction, Maintenance and Operation Draft title) as examples important to experts team members end reviewers. All interested to collaborate and coauthor are invited to join the team. We are very excited about the idea of doing a "hydraulic failures" as a key project for the time ahead.

B. Cooperation in preparing the new ASME Guide edition

Cooperation with ASME Hydro Power Technical Committee in editing and reviewing *The Guide to Hydropower Mechanical Design*, planned for February 2009.